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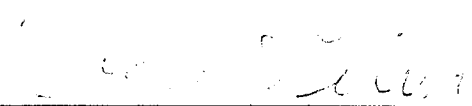
Final Technical Report
Grant No. NCC-2826: 'Advancing the Science Experiences of Young Children 2-5 Years'
to:

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
AMES-DRYDEN FLIGHT RESEARCH FACILITY

Submitted by

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Summary of Final Progress Report:

The goal of this project was the development of a program of science and mathematics activities that is suitable for use in preschool and daycare settings, for children before they enter kindergarten. More and more members of the business, government, education and military communities are calling for a notable upgrading of the scientific and technical literacy levels of our all of our citizens. Many are encouraging educators to introduce children to relevant learning opportunities at early ages. Two lines of work converge on the suitability of this recommendation. More and more we are seeing how important early learning experiences are for later successful development. Second, research with preschool aged children shows that they do have some conceptual understandings of scientific and mathematical knowledge, ones that can provide a conceptual foundation with which to engage activities about the content and methods of science. Given our own work on the nature of early conceptual competence, we judged that it would be possible to develop suitable preschool learning activities that can support the development of scientific intuitions about: the causal conditions for change and/movement of animate and inanimate objects (that are separably moveable); the similarity and differences between different kinds of plant life and the causal factors that contribute to their growth and form; the role of different energy sources; and scientific ways of thinking, talking and working -- including experimenting, predicting, checking, measuring and record keeping. The idea was to move young children onto science-relevant learning paths, ones that would facilitate their learning about science in the more formal learning opportunities they will encounter in school. To do this we established a unique collaboration between classroom teachers, UCLA researchers who specialize in early learning of mathematical and scientific concepts/tools, and the UCLA Child Care Services program. We also planned to help develop a community of teacher-researchers as part of our dissemination efforts. R. Gelman headed the research team who over the period of the grant have included Dr. Lisa Travis, Earl Williams, Stephanie Reich and Osnat Zur; Susan Woods and Gay Macdonald headed the on-site school team.

We achieved our objectives as evidenced by the writing of a draft of a preschool teachers' guidebook entitled: *Preschool Pathways to Science: Facilitating, Scientific Ways of Thinking, Talking, & Working*. The version we have is still in draft form; still it is well along in production to both constitute the body of our Final Report to NASA and serve Susan Woods efforts to train teachers at the new opened University Children's Village, a UCLA Child Care Service facility for children of graduate students and other low income families.

Woods, a teacher who worked closely with us and is now Director of the Bellagio site of the UCLA Child Care Services program, is training teachers at a The University Children's Village, a newly opened UCLA Child Care Services site for an ethnically and culturally diverse group of children and their families. Dr. Gelman is using other funding sources to make sure that members of her team continue with the Guidebook and see it through to publication. Reich and Zur are observing and recording the training sessions that Woods is holding. We will use the results of both the teachers' learning session and subsequent applications to their classrooms to add a section to the guidebook on how to put the recommendations into action. We expect that this kind of information will also help us pinpoint potential sources of confusion or misunderstanding that need to be addressed in the final version of the guidebook.

NOTE: At the moment the Guidebook is entitled *Preschool Pathways to Science*. We welcome advice from NASA as to whether the title should be something like the *UCLA-NASA Preschool Pathways to Science*. In particular, we are eager to know how NASA wants us to acknowledge their critical support of this product. Already I have had several requests for either the materials or my input as a consultant. These include ones from the Sesame Street production team who are planning to embed science material in their programs.

Preschool Pathways to Science

Facilitating Scientific Ways of Thinking, Talking, & Working©

Teacher Guidebook

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Preschool Pathways to Science (PPS): Facilitating Scientific Ways of Thinking, Talking, & Working

Teacher Guidebook

The Preschool Pathways to Science (PPS) Program provides early childhood educators with a flexible approach to science exploration for young children. This program has been developed and tested over a three-year period by a team of dedicated preschool teachers, preschool directors, and developmental psychologists who specialize in cognitive development and science education. We believe that the Preschool Pathways to Science approach is developmentally appropriate for young children, enjoyable for both children and teachers, and also practical to implement. It builds on the foundation of experience that teachers and directors already possess, including their knowledge of time-tested and developmentally appropriate activities. Preschool Pathways to Science has been developed in preschool settings with four-year-olds, but we believe that Preschool Pathways to Science is equally well suited to kindergarten and early elementary school classrooms. Elements of the program can also be successfully explored with younger preschool children. We are confident that in reading this Guidebook, you will find that many Preschool Pathways to Science methods, ideas, and activities are already familiar to you. We also hope that you will become as excited as we have about the possibilities of the Preschool Pathways to Science approach, and about applying it in your own classroom. Your reward will be the children's enthusiastic involvement in doing and talking about their ideas for experiments, what to measure, and how something changes or moves.

Play and "hands-on" exploratory activities provide important learning opportunities for young children. However, without appropriate teacher guidance and support, these learning opportunities can easily be missed. This is particularly true of early science learning. Since many abstract concepts (such as growth or cause) cannot be perceived directly, children cannot discover them through unguided perceptual exploration. In our approach, children acquire science skills and knowledge not just by "doing", but also by thinking and talking about what they are doing. As you will see, this approach fits well with a wide variety of familiar preschool activities, including Group Time and Show & Tell.

The overall purpose of the Preschool Pathways to Science program is to facilitate children's development of scientific ways of thinking, talking, and working. These skills include observing, comparing, asking questions, predicting, testing, measuring, and recording. We call these skills "scientific tools." Science education in secondary school and even elementary school may be largely centered on teaching facts, but the Preschool Pathways to Science program is not. Teachers do not directly "teach" science facts in the Preschool Pathways to Science program, nor do they work their way through a fixed set of activity recipes. Instead they plan, nurture, and guide children onto science learning paths. They offer meaningful activities and supportive learning environments in which children can develop and apply their scientific tools.

An emphasis on connecting and relating forms a central component of these learning environments. Children are constantly encouraged to draw connections between activities and ideas, to apply questions and solutions from one activity to another, and to understand transformations and sequences which unfold slowly. We have found that children's best and deepest learning often occurs when given the opportunities to develop connections and insights. By building from ordinary preschool activities such as growing plants and cutting open pumpkins, the Preschool Pathways to Science approach repeatedly weaves children's use of scientific tools into an interconnected series of learning opportunities ("pathways"). During a year many opportunities to become actively engaged in scientific ways of thinking and talking occur and children do discover underlying science facts and general concepts. Children understand and remember these facts much better by actively discovering them than by passively hearing and memorizing them. After the Preschool Pathways to Science program, children are in a position to apply their discoveries and scientific tools in their future science learning, as well as elsewhere in their daily lives. They are on science learning pathways.

The goal of the Preschool Pathways to Science is to help teachers do what we have found they like to do, provide their children with a range of engaging science activities that are consistent with many recent findings about the cognitive abilities of young children. Our suggestions are based on our efforts to do this with the children we have worked with over the past three or four years. Indeed, it is the teachers' escalating excitement about their children's learning directions that led us to share our efforts in this Guidebook.

General Questions

Here are answers to some questions you may already have about PPS:

- Is the PPS program a fixed curriculum of science units?
Definitely not. We expect and encourage each teacher and school to implement the flexible PPS approach in their own unique way. You should adjust PPS to fit your school's resources and needs, rather than

forcing yourself to adjust to it. For example, the PPS program can benefit both newer and more experienced teachers. Newer teachers can get ideas for good science-related activities and how to encourage connections between them. Expert teachers can go deeper, using PPS ideas to build on their existing base of successful activities and techniques. For every teacher, PPS is definitely not "Yet Another Program" which would require them to replace things that they already do well.

- Are young children developmentally ready to learn about science, and should they start in preschool?

Yes and yes! Contrary to what was once thought, the last twenty years of cognitive development research have shown that preschoolers are developmentally ready to think about, talk about, and understand a variety of science-related topics. Young children are not limited to thinking solely about concrete concepts in the present. There are many way in which they can successfully handle abstract concepts such as causality, time, and number. Four-year-olds and even younger children enjoy talking about the past, thinking about how things change over time, and making predictions about the future. They can apply ideas from yesterday, last week, or last month to the current discussion or activity. Our everyday world is rich with opportunities for early science learning experiences. Here are a few examples of four-year-old children applying scientific tools (some examples combine more than one tool):

- **Comparing.** Child, looking at two pieces of grapefruit, one fresh and one moldy: "One maybe is got rotten." Teacher: "What are the differences?" Child: "Color. One is brown and the other is yellow."
- **Experimenting.** Teacher: "A good idea would be to make an experiment to see whether the wet ones [strawberries] will mold fast or the dry ones. How would we do that?" Child #1: "Make an experiment. Put them in the refrigerator, let them stay for awhile, and then we will see which one is moldier than the other." Child #2: "Try it." Teacher: "That is why we do an experiment." Child #1: "Because we don't know yet."
- **Predicting & Testing.** Teacher: "Which jar do you think is going to turn into butter faster, the one that is colder or the one that is warmer?" Child, while feeling the two jars: "The one that is colder cause it freezes up faster."
- **Time & Change.** Teacher, looking at caterpillars: "They are making themselves cocoons." Child: "Can I make a prediction? They are going to be butterflies."

- **Insides & Outsides.** During a discussion of the insides and outsides of things. Teacher: "Clouds, What are they made out of?" Child: water, tiny drops? Teacher: "steam, where do we see steam besides the kitchen?" Child: "in the bath tub...on the train." Teacher: "how about on a cold day?" Child: You blow it out your mouth...the inside of us is warmer than the outside."
- **Measurement.** Child, one of three girls measuring each other with measuring tapes: "Six inches -- Mary's feet is bigger than you...You are 26, I'm 40, I'm bigger than you."
- **Journaling and Record keeping.** On a regular basis throughout the summer, children get out their science journals and draw sunflower plants in the garden. Each drawing shows the flowers at a different point in their growth, from seeds up to tall flowers. They also use stamps to date their work, just as scientists do.

Children can learn best when we challenge them to push the edges of their development, where their knowledge is neither too secure nor too underdeveloped. We should take advantage of children's readiness and start them toward scientific literacy. Starting early to develop a sound conceptual base in the sciences is important for several reasons. First, it makes sense to spread out the number of science concepts and vocabulary terms that children must eventually learn. Second, early science learning may make it easier to overcome common misconceptions which are obstacles to later science education. Finally, by encouraging children to ask questions and find answers, we can encourage their critical thinking skills (a goal that teachers like to keep in mind).

- Can PPS really be implemented by any teacher?
Yes, because the program emphasizes scientific ways of thinking, talking, and working with topics children like, as opposed to memorization of "scientific facts". No lengthy teacher training is required: at one school where we introduced the PPS approach, teachers were off and running after only three group staff meetings. We have found that teachers quickly discover that they can facilitate successful and interconnected science experiences for their children. This process creates an enthusiasm in the classroom which takes root and continues to build throughout the school year. The PPS approach gives teachers an opportunity to exercise their own creativity while facilitating children's discovery and sharing in their explorations. It is not about lecturing, or inflexibly delivering a canned curriculum.
- Does the PPS program really fit into the structure of the preschool day, and can it be integrated with a program that is already in place?
Absolutely. Discussions in Group Time are an ideal way to introduce

questions and ideas, encourage children's input, and demonstrate follow-up activities. At other times, science-related activities become an additional choice for children, co-existing and blending with the many alternative activities which are available both inside and outside the classroom. By providing repeated opportunities for exploration and learning over the long term, the PPS approach allows each child to follow their own learning pathway. Not every child is expected to participate on every day or in every activity. By integrating science into every activity center, rather than just a "Science Table," we can increase the chances of reaching each individual child by presenting an activity that captures their attention and interest.

The PPS program does not take over or push aside the program that you already have in place. Instead, you can use the PPS framework (see Section 1 below) to plan connections between science-related activities, and to add scientific perspectives and tools to children's repertoire of ways to interact with the world. The framework builds on teachers' existing foundation of developmentally appropriate activities, for which most of the equipment and materials are already in place. For example, if you use a season- or holiday-based curriculum, many familiar activities can easily be worked into the PPS framework: collecting leaves in fall, carving pumpkins on Halloween, or washing pennies on President's Day. If you are already using a "literature-based" or other long-term framework, the PPS framework can readily overlay it to take advantage of existing connections while also building new science-related connections. If you already have successful science-related "themes", you can easily use them as starting points from which to build the PPS framework (see examples in Section 1 below).

In any case, children quickly come to extend their new ways of thinking, talking, and working into additional science activities even at lunch time or during dramatic play. For instance, children may predict the number of seeds inside an apple, or use measuring tools when building with blocks. These extensions do not need to be planned by the teacher, since they often occur between children rather than between teacher and child. Instead, teachers get good at using their "antennae", noticing and encouraging these teachable moments whenever and wherever they occur. Once encouraged, children expect their science learning to not be limited to "Science Time" or a "Science Table."

Related Themes in Early Childhood Education

Two recent publications have been aimed specifically at modernizing early science education practices. In 1995, the National Association for the Education of Young Children (NAEYC) published a book entitled Reaching Potentials:

Transforming Early Childhood Curriculum and Assessment (Vol. 2), which contains a chapter on science education for young children. In 1996, the National Research Council (part of the National Academy of Sciences) published the new National Science Education Standards aimed at K-12 science education. In general, the PPS program has been developed during an exciting time for early childhood education, with many ideas and approaches starting to replace more traditional teaching methods. As you read this Guidebook, you may be reminded of some or all of the following:

- The Emergent Curriculum, with the teacher as facilitator and not lecturer
- Active, "Hands-On" exploration
- The Integrated Day
- Webbing
- Techniques at the Reggio Emilia preschool in Italy
- Lev Vygotsky and the "zone of proximal development"
- Jean Piaget's view of children as active learners who construct their understanding of the world

There are many similarities between these existing terms/phrases/ideas and our approach. Still, there are enough differences, which is why we prefer other ways of describing the PPS program's details. We do not to ignore these ideas. However we are concerned about meanings and interpretations we do not want intend. An example is the term "hands-on learning", which was originally advocated as a positive alternative to passive, desk-bound learning activities. Too often, however, "hands-on" has now come to mean nothing more than "on your hands." Active learning is undeniably important, particularly for young children, but it does require some guidance and facilitation by teachers for that exploration to follow productive learning pathways. This teacher guidance is what makes activities "minds-on" rather than just "hands-on". Children are encouraged not just to have experiences but to think about them and talk about them in scientific ways. What makes the PPS program unique is that it provides teachers with a flexible approach to giving children this guidance, while also preserving the advantages of child-initiated learning. General guidelines and suggestions are only useful up to a point; PPS offers a concrete method for implementing a "minds-on" science program in a practical and developmentally appropriate manner.

Over the past two years, we have had the opportunity to present the PPS approach to many preschool teachers and directors. In the very beginning, we have often encountered a common set of reactions to the idea of teaching science to preschoolers. These reactions include ambivalence about the usefulness of the program, and apprehension about implementing it. If you share some of these feelings, we hope that this Introduction has begun to reassure you about the following concerns:

- Whether preschool children are ready to learn science (yes), and whether it is appropriate to start science learning in preschool (yes).
- Whether you as a teacher will have to learn and “teach” difficult science facts (no), or follow a fixed curriculum (no).
- Whether you will be able to comfortably integrate science into a preschool setting (yes), and into the program which you already have in place (yes!).

Here is a preview of what you will find in the rest of the Guidebook:

- Section 1:** An overview of the PPS Framework, which facilitates both teacher-guided and child-initiated connections between science activities throughout the year.
- Section 2:** How to prepare yourself, your classroom, and your support staff, and how to develop your initial plans for implementing the PPS Framework.
- Section 3:** How to introduce scientific ways of thinking, talking, and working into your classroom, so that they take root and children start using them spontaneously.
- Section 4:** Sample ideas from our own PPS experiences, with examples of scientific tools in action.

We emphasize once more that Preschool Pathways to Science is an approach, not a curriculum, and so what follows must not be thought of as a strict recipe. There is no such thing as “starting too late”, “falling behind”, or “missing a step.” What matters is that you provide lots of opportunities across the year. You are the one who decides how the PPS approach should be implemented in your particular classroom. Make Pathways to Preschool Science your own!

Section 1. Overview of the PPS Framework: Making Connections

Adding the PPS approach to a preschool classroom involves providing a connected series of learning experiences, in which children are introduced to a set of skills which we call scientific tools. The teacher's role has three basic parts:

- Using the PPS Framework (see below) to develop science-relevant and developmentally appropriate activities, and to help children draw connections between activities and ideas.
- Introducing and using scientific ways of thinking and talking wherever possible: asking open-ended questions, requesting comparisons/ predictions/ observations, and regularly using scientific words such as "predict", "test", and "observe".
- Introducing and facilitating scientific ways of working, by adding a variety of tools to the learning environment. These include tools for observation (such as magnifying glasses), measurement (such as rulers and scales), and recording (such as journals, date stampers, and perhaps even cameras).

At the heart of our approach is the PPS Framework. The primary goal of the Framework is to provide structure to children's activities, so that they are connected by shared scientific ideas and concepts across time. Teachers and classroom staff use the Framework in their planning, so that they prepare and guide their children toward activities which are readily connectable. In this way, the connections which teachers anticipate and plan for can often be "discovered" by the children instead of always being "taught" by the teacher. This process of discovery and exploration by the children is more important than the learning of specific facts or concepts.

Many preschool teachers already have a repertoire of highly successful and developmentally appropriate science activities. However, these activities are often not connected, or are not pursued long enough to give children the time they need in order to make discoveries and grasp underlying science concepts. Children have longer attention spans than they are sometimes given credit for. In our experience, they like it when they are given time to observe and think, rather than continually rushing on to new activities. Activities which are connected by a subject, an idea, or a question can give children this time they need.

There are some key notions that organized our presentation of learning opportunities throughout the school year. One of these is the idea of a **Central Concept**. Like an onion, the central concept is at the core of a related set of concepts that belong together. For example, our intuitions about the central concept, "animate object" organizes together some critical ideas about animals,

including how they move, that they need nutrition, that they have internal parts that support the capacities to move, and so on. The related central concept, inanimate object, organizes our intuitions about how things like balls, dolls, bikes, etc. move. For example, we know that none of these inanimate objects move themselves. In contrast, we know that animate objects do move themselves. Research shows that preschool children are able to grasp this difference and so we tried out a series of activities designed to offer children opportunities to build on their beginning understandings. Another central concept, "insides and outsides", was used to organize circle time and follow-up activities on the way fruits and plants are alike and different, an important way that machines and animals differ, and so on.

A central concept goes hand in hand with the choice of a **Conceptual Focus**. Children are able to explore the central concept differences between Insides and Outsides through the hands-on conceptual focus of Fruits vs. Vegetables with hands-on activities. This conceptual focus led to a series of activities on opening up fruits and vegetables, comparing and contrasting the insides and outsides, classification games that switched between looking for ways that things were alike and different on the inside, alike and different on the outside, predictions, and recording (by drawing) what the children saw. The conceptual focus, "growth", also can be related to the inside-outside idea. For example, teachers can make up activities for children to explore the insides of plants as they grow.

Activities should be made available for many days, both to increase the number of children who participate and to give children the time necessary to explore them thoroughly. By giving children plenty of time with an Activity, they also have the chance to notice and explore links between Activities from the same Conceptual Focus, as well as from different Conceptual Focuses. This repetition (with variation) across Activities allows children to assemble a coherent body of knowledge about a Conceptual Focus area. Each different example and different perspective on a Conceptual Focus provides them with additional knowledge. They also learn the issues and questions that are particularly relevant to the general area. Children can learn more through repeat experiences as well as more time. Over the year, in lots of different ways, children can learn to integrate the different central concepts, conceptual focuses, and activities.

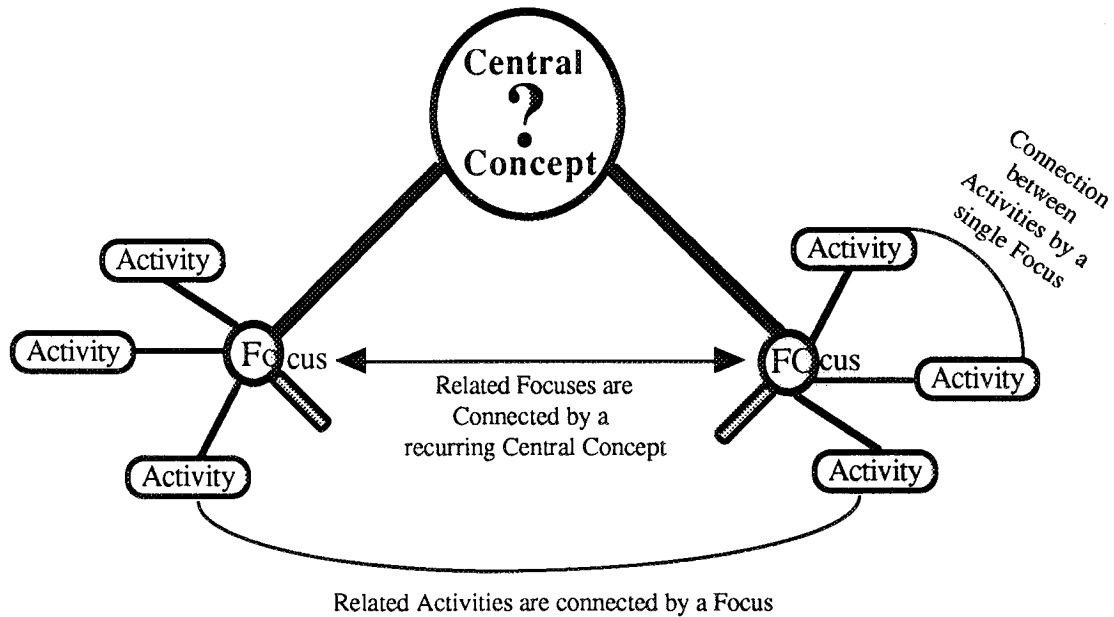
There is yet another reason to give children plenty of time with an Activity, a lesson that we were sometimes slow to recognize (see Appendix B). Children must be given the opportunity to explore materials and tools on their own, unguided. Once their initial curiosity has been satisfied, children are better able to concentrate on the particular activity that we want them to do with those materials, or on the particular question that we want them to consider. For example, during the week prior to an Activity that involved planting seeds in pots, we put pots and seeds of different sizes on a table in the classroom.

Without being prompted, children played with the pots and seeds in all the usual preschool ways: counting, stacking, ordering, and so on. When the day came to plant the seeds, children were already interested in the seeds and pots and ready to work with them in a new way.

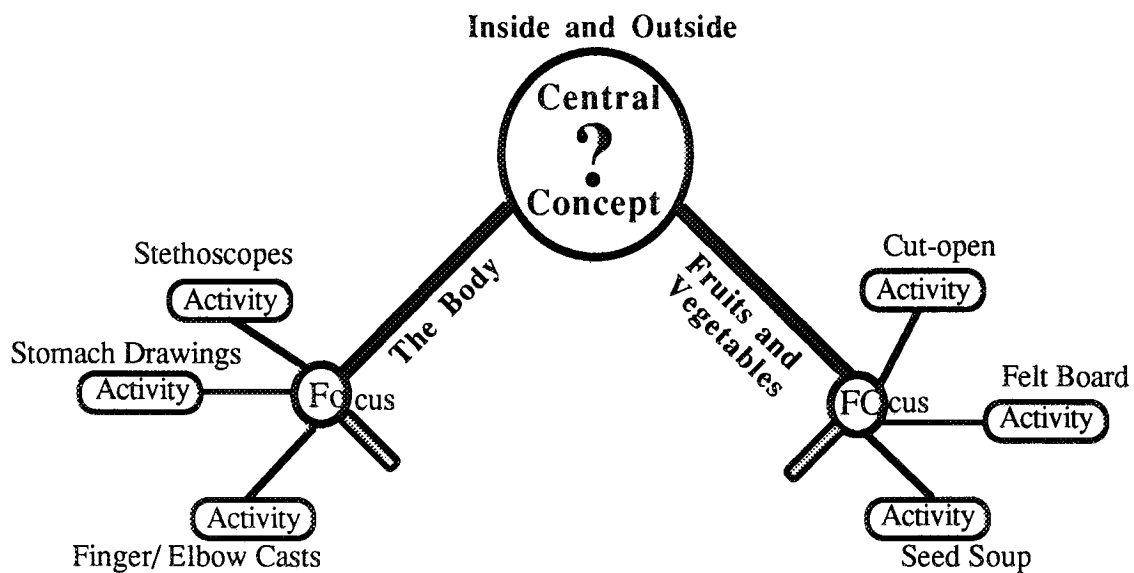
Over a period of months, related Conceptual Focuses are linked and unified by a single Central Concept. A Central Concept is a very broad and open-ended question/topic, a sort of lens through which each Conceptual Focus and its Activities can be viewed. For example, a Central Concept of “Change” could be explored through Conceptual Focuses including “Hot and Cold”, “Wet and Dry”, and “Liquids and Solids.” Central Concepts generally last for two or three months, although questions and solutions learned with one Central Concept often carry over into the next. By repeatedly considering a Central Concept during Activities in several different Focuses, children learn to make general inferences, and discover concepts about the Central Concept on their own (for example, “all living things need water”). The differences between a Conceptual Focus and a Central Concept are discussed further below, under “Getting the Framework Ready” (Section 2).

On the next page is a figure that illustrates the relationship between the three elements of the PPS Framework. Sets of **Activities** cluster around each **Conceptual Focus**, and several **Conceptual Focuses** are unified by a **Central Concept**. For visual clarity, only some of the many connections between Activities and Focuses are shown; these connections are discussed below.

Connections and the PPS Framework: A Central Concept, Conceptual Focuses, and Activities



Sample Connections of a Central Concept, Conceptual Focuses, and Activities



The PPS Framework is a tool for teachers and staff to use in mapping out activities and planning for connections. The idea is not to teach children the Framework itself. The children's experience of PPS is through Activities in which they keep hearing about and using certain questions, ideas, phrases, and tools (which their teachers know are from Conceptual Focuses and the current Central Concept). In the following sections, you will learn more about the following:

- How to get ready to implement the PPS Framework in your classroom.
- What makes a good Activity, Conceptual Focus, and Central Concept (and how a Conceptual Focus is different from a Central Concept).
- How to plan for connections and not always teach them directly.
- How to help children develop scientific tools, including new ways of thinking, talking, and working.

Section 2. Getting Ready to Start the PPS Program

Getting Yourself Ready (the Teacher)

In the PPS approach, the teacher's primary role is to facilitate children's opportunities to make discoveries and draw connections about central concepts and related tools. This requires a somewhat different attitude toward planning than is required by traditional science curriculums. In particular, the PPS approach requires the teacher to think ahead about what the goals are, not just for the day's Activity but for other connected Activities and Conceptual Focuses in the future. By anticipating fruitful connections and pathways, the teacher can help children to "discover" these connections during the following days, weeks, and months. Teachers introduce and guide activities so as to connect them to the current Central Concept and Conceptual Focus, rather than presenting them one at a time as isolated events.

The PPS approach has a high degree of flexibility, because it recognizes and encourages children's active participation in their own learning. While some connections are anticipated by the teacher, other connections will emerge spontaneously, drawn by the children. The teacher should allow these child-initiated connections to flourish, adding Activities or even Conceptual Focuses where possible to follow up and keep the class engaged with the Central Concept. In general, Central Concepts are chosen and maintained by the teacher and staff, while Activities are the most emergent (child-guided) part of the program. For example, one of our children brought in his own experiment of seeds in wet and dry tubes; we took his idea and built it into a class-wide experiment. The choice of Conceptual Focuses is a middle ground: usually guided by the teacher, but sometimes suggested by interests and ideas picked up from the children.

The following example illustrates the balance between advance planning and emergent flexibility just described. At one point in our school year, the Central Concept was "Insides and Outsides," and two different Conceptual Focuses were in progress: "Fruits & Vegetables", and "Inside the Body."

During an Activity with fruits and vegetables, a discussion turned to the question of what happens to food inside our bodies. The next Activity picked up on this question: children used stethoscopes to listen to food being chewed in their mouths and digested in their stomachs. The use of stethoscopes brought up the topic of bones, and so the next Activity involved the use of finger splints and casts to explore how bones move in some ways but not others. The topic of bones led to children's interest in dinosaurs and fossils, so the next Activity involved making "fish fossils" by pressing fish skeletons into plaster. During this extended sequence of four Activities (over more than a week), the teacher kept bringing up the two Conceptual Focuses, and always in the context of the Central Concept: learning about Insides and Outsides by making comparisons and distinctions. By anticipating the directions that children might explore with

an Activity, she could prepare follow-up Activities that took children's interests in new directions. At the same time, she could keep the class on the pathway of Focuses and a Central Concept that she had planned.

The PPS Framework therefore combines teacher-directed and child-directed influences, and is consistent with the trend in early childhood education toward an emergent curriculum. It gives children some control over the learning pathways they follow, which necessarily means that the teacher does not have total control. Children's active role in their own learning has several implications, which often are unrecognized or under-appreciated:

- Teachers must be sensitive to the fact that children may not always interpret their guidance in the way that was intended, or carry out an activity in the way that was planned. Teachers should not regard such an occurrence as a failure on their part, but rather as a positive sign of children's active engagement in the activity and an opportunity to provide hints.
- Teachers should look for ways to encourage children to contribute their own ideas. Children should be shown that their ideas are valued by the way in which they emergently influence Activities.
- As discussed above, the amount of time that an activity is available should depend in part on children's level of interest. Children often remain interested in an activity much longer than adults would guess (usually days, not just minutes or hours). Teachers should observe children's activity level in order to determine whether the class has tired of an activity, since children don't necessarily tell us when they've had enough. Rather than directly giving children answers and solutions, we should give them the time they need to think. This allows them to make discoveries for themselves.

For any teacher, striking a balance between advance planning and emergent flexibility is both a challenging and rewarding task. On the one hand, achieving an appropriate balance is exciting because of its very unpredictability: something new is always happening, the program is never exactly the same from one year to the next, and you can share children's pride in their own discoveries. On the other hand, flexibility can sometimes be a bit scary, and this anxiety is entirely understandable. If we can offer any reassurance, it is our belief that you will soon find the rewards far outweighing the occasional moments of uncertainty.

Flexibility is good for everyone: the children, the teacher, and the support staff. If an Activity or a Focus isn't working out, or children are unable to concentrate on science activities for one reason or another, it's perfectly OK to let it go and try something else (perhaps it's Fire Prevention Week, or the last day

before vacation). One thing you can count on is that activities and discussions will sometimes go off in unplanned directions (see Appendix B). Rather than struggling to force children back onto your intended pathway, it is often better to examine why the activity took the path it did, and then try to integrate that new direction into the PPS Framework you have planned. There is always room for improvement and refinement. PPS is an approach in which teachers guide children's growth while also continuing to grow themselves.

Getting Your Staff, Classroom, and Parents Ready

Even if you as a teacher are comfortable with the flexibility and advance planning which makes the PPS program run at its best, you may find that you have other people to convince - your director, partner, assistant teachers, parents. You may get an initial reaction similar to what we heard from one of our teacher assistants in an introductory meeting: "Something that could benefit us is if you could write what you want us to do during the whole year or monthly so that we could follow that and prepare for the next assignment." If some of your staff is accustomed to planning in terms of a recipe-oriented approach, part of your task to bring them on board is to teach them the alternative approach that PPS involves. The thematic-based model of education can be hard to budge, but you can convince your staff by showing them how well children can do in an approach which is both guided and emergent.

In staff meetings, you can draw co-workers into the process of planning the Framework, so that they take an increasingly active role in planning Conceptual Focuses and Activities and not simply executing your plan. You will probably also want to discuss the questions and concerns addressed above in the Introduction section of this Guidebook (pages 2-4). Your staff should know that it's OK to trust their experience and intuitions about what children are capable of. Your staff may initially misinterpret the mere mention of the word "science" as "Let's teach difficult science facts that I haven't thought about since high school and will have to find time to re-learn well enough to actually teach." Be sure to relieve any such anxieties early and often, whether or not anyone says them out loud. It is particularly important that you discuss the PPS Framework with your staff: what makes a good Central Concept and a good Conceptual Focus (and how they are different), and how to connect Activities in different Conceptual Focuses to a single Central Concept.

In addition to preparing your staff for the PPS program, there are several things you can do to prepare the learning environment both inside and outside the classroom. The most important preparation to do is to add measurement and observation tools throughout the classroom. Rulers, measuring cups, magnifying glasses, and scales can be used not just at a Science Table but everywhere. To give just a few examples, we put a grocery scale in the dramatic play area, measuring cups in the kitchen area, and rulers near the blocks area.

These tools need not be put out all at once, and children need not be directly taught how to use them. Allow children to explore them unguided at first, rather than immediately focusing on correct usage (such as using the correct units on a ruler). Another important tool is each child's science journal (see Section 3 for how to introduce these physical tools, as well as scientific ways of thinking and talking).

Finally, you may find it useful to prepare your children's parents for the PPS program. A letter to parents can describe the program, including scientific language and activities to expect. One such activity that we have found to be very useful is bringing things from home (you may choose to call this activity "homework", although it rarely requires much work at home). In our experience, homework has been particularly successful at drawing children out, and giving them emergent opportunities to shape the program's direction. It can also be an excellent means for making connections across activities. If parents understand the role played by homework, as well as the ways of thinking and talking that their children are learning, they will be in a better position to encourage and assist their children at home. A sample letter to parents appears in Appendix A.

Getting the Framework Ready

As you prepare to introduce the PPS program into your classroom, the process of planning your Framework begins. This involves choosing your first Central Concept, choosing your first two or three Conceptual Focuses on that Central Concept, and lining up an initial set of Activities to start off each Conceptual Focus. These choices need not be made in this particular order; you may start with a set of Activities you like, choose some Conceptual Focuses that connect them, and then choose a Central Concept which can be considered with every Conceptual Focus. Feel free to develop your Framework however you like. This section will discuss how to choose a Central Concept, Conceptual Focus, and Activity. Section 3 will discuss how to introduce Activities and scientific tools to your children, and start making connections between Activities.

As mentioned earlier, we encourage teachers to involve their support staff in the process of building the Framework, both through staff meetings and during Activities themselves (when children provide ideas and input). One exercise that can be useful when you are first planning out your Framework is to ask each member of your staff to bring in their favorite science-related project(s). You can then see whether many or all of these time-tested favorites can be used as Activities, or even expanded into Conceptual Focuses. This will increase your staff's feeling of ownership of the PPS program, and set an immediate example of how their input and experience is welcomed within the flexible PPS approach.

What makes a good Central Concept? A Central Concept must capture a very broad and open-ended question or issue, one that children can repeatedly consider through different Focuses over a lengthy period of time (months). By contrast, a Conceptual Focus (see below) is more specific: a topic or area of knowledge which children explore through various Activities over the course of a few weeks. A Central Concept should capture children's interest and be developmentally appropriate. It must be relevant to science. Finally, it should be a good fit to the available activities and resources of your particular school.

Contrast is a powerful factor in many good Central Concepts (though it is not the only one). Children often find it easier to think about and learn things by contrast rather than individually. For instance, it is easier to talk about Insides by contrast to Outsides than it is to talk about Insides alone. There are many ways to create contrasts: one thing vs. another, two different aspects of one thing, changes in the same thing at different times or places, and so on. In the first column of the following table are some examples of good Central Concepts, most of which involve contrasts, and many of which we have successfully implemented with four-year-olds. The second column shows ideas that we think would not make a good Central Concept, either because they are not broad enough or relevant enough to science. Most of them could work well as Focuses, however.

Good Central Concepts

- Change and Causality
- Animate vs. Inanimate Objects
- Insides vs. Outsides
- Movement
- Life, Life Cycle
- Growth
- Animals vs. Plants
- Scale (size)
- Energy

Not Central Concepts

- Magnetism
- Transportation
- Dinosaurs
- Sea Life (another specific area of knowledge, instead of a broad question or issue)
- Seasons (a bit short for a Central Concept)
- Outer Space (probably few available resources for concrete Activities)

A Central Concept plays a central role in unifying different Conceptual Focuses because the teacher and support staff continually bring it up as a topic for discussion. Most of the flexibility and emergent nature of the PPS program is in the Conceptual Focuses and Activities; Central Concepts are set by the teacher, and they keep the class "on the main path" no matter what the current Conceptual Focuses and Activities happen to be.

What makes a good Conceptual Focus, within the current Central Concept? Conceptual Focuses should allow children to consider the Central Concept from several different perspectives, using Activities which are based on a variety of related topics and questions. For example, with Change as a Central Concept, different Conceptual Focuses could look at various kinds of change.

There are reversible changes (hot <-> cold, liquid <-> solid, wet <-> dry), irreversible changes (raw -> cooked, young -> old), and cycle-based changes (seasons, days of week). There are fast changes and slow changes. There are outdoor changes and indoor changes. Each Conceptual Focus considers the Central Concept of Change in a slightly different way.

Here are a few additional ideas for Conceptual Focuses within some Central Concepts:

<u>Potential Central Concepts</u>	<u>Potential Conceptual Focuses</u>
Insides & Outsides	<ul style="list-style-type: none"> • Fruits and Vegetables • The Body
Movement	<ul style="list-style-type: none"> • Transportation • Animals and Vehicles

Conceptual Focuses should be broad enough that they connect more than one Activity. Wherever possible, they should be also planned so as to take advantage of natural connections. For example, there are many natural connections between the Conceptual Focuses “liquid <-> solid” and “raw <-> cooked”. The class can consider as many as two or three Focuses at a time. This is particularly true when you allow children’s input to emergently guide your choice of Focuses. Conceptual Focuses are the most emergent part of the program: New Conceptual Focuses can be introduced based on children’s contributions of ideas, questions, and things from home. “That’s a good idea; let’s try it!”

Finally, what makes a good **Activity** that will work well within a Conceptual Focus? Beyond being enjoyable and developmentally appropriate, a good Activity provides a context in which children can talk with each other and with the teacher about the current Conceptual Focus(es) and Central Concept. Through a series of connected Activities, children can discover relationships and science concepts. For example, through a variety of Activities dealing with water, children can discover that “living things need water” in a more effective way than if the teacher simply taught them this fact. Activities should be child-driven rather than teacher-driven, and should be made available to children for more than just a single day or part of a day. A format which has worked well for us is to introduce Activities and discuss ideas in Group Time, and then to follow up on those discussions with Activities which are available during free play immediately afterward. Not all the children will choose to participate right away, and in fact it would be impossible to accommodate them all at once if they did. Eventually, however, most children will give them a try.

Here a few ideas for Activities within some of the Conceptual Focuses listed above:

<u>Potential Central Concepts</u>	<u>Potential Focuses</u>	<u>Potential Activities</u>
Insides & Outsides	Fruits and Vegetables	<ul style="list-style-type: none"> • Cutting them open to compare insides • Sorting them according to whether they have seeds or not • Predicting the number of seeds inside
	The Body	<ul style="list-style-type: none"> • Drawing what's inside the stomach • Measuring the length of bones • Putting casts/splints on fingers

Section 3. Starting Out

Introducing a Central Concept.

There is certainly no one “correct” way to introduce a Central Concept. A method which has been successful for us is to make use of Group Time, when the attention of most children is engaged. Briefly bring up an issue, repeatedly using the key term(s) in the Central Concept, and then ask a general question which many children will answer. Here are two examples, for the Central Concept of “Change” and “Insides / Outsides”:

Teacher: “I’ve been thinking about things that change. There are lots of things that change. Who can think of something that changes?”

Teacher: “I’ve been thinking about insides and outsides. Lots of things are different on the inside than they are on the outside. Who can think of something that has a inside and an outside? What are they like?”

With such general, interesting, and confidence-building questions as these, children should soon start calling out answers from a variety of areas. Let this early discussion be largely child-directed; you can pursue the directions they lead, asking follow-up questions which encourage further answers (what, how, etc.). You will probably already have in mind at least some of the Conceptual Focuses you plan to pursue during the upcoming months; look for and highlight children’s answers in these areas. The key is to promote lively participation from the children by asking only open-ended questions. Avoid questions that have only one right answer, or that can be answered with a short “Yes” or “No.”

Introducing Scientific Ways of Thinking and Talking

Much of the PPS approach revolves around children thinking out loud in scientific ways, particularly the following:

- predicting and testing
- explaining why
- comparing
- making connections
- presenting results of a tested prediction

Some children will be naturally inclined to talk more than others, and one of the most important things you can do early on is create a supportive classroom environment. This is particularly true of Group Time, where many discussions

take place. Meaningful efforts by a child to participate should be attentively listened to, praised, and responded to.

You and your staff should make a list of scientific terms that you will begin to use in science-related discussions. A simple list could start with the words "predict", "test", and "measure". Early in the year, several Group Time discussions could be devoted just to introducing the terms "prediction" and "testing." Later on, when things are flowing more, children will say things like "I'd like to test something," "Look what I discovered," or "I'd like to make a prediction." Prediction is not the same as guessing; we make a prediction about what will happen in the future, because we have a reason to think that things will turn out a particular way, and then we can test that prediction. A prediction is what we think the answer to a question might be whose answer is unknown, but about which we know enough to do more than just guess. We do not predict what the next number after 4 is, because we already know, but we can make a prediction about how many seeds we will find inside an apple when we cut it open.

To introduce your class to predictions, start by asking the whole group an open-ended question. For example, while shaking a box with several objects inside, ask the children, "What is inside this box?" Try to avoid questions for which the answer is already known ("What is 1+1?") or immediately perceivable ("What color is this apple?"). Then get a variety of predictions from the class, and encourage more and more predictions until nobody will give any more. At first, you may face the "one right answer" barrier; many children will think that every question has only one right answer, which is either known immediately or is a complete mystery. By asking open-ended questions, you can teach your children that questions are not just fact-checking tests. Some questions remain a mystery until we make predictions and then test them.

After listening to the children's predictions, you can go around again to ask for the reasons why they made their predictions. It is important to ask these "Why" questions in a non-threatening manner. For many children, the question, "Why do you say that?" translates to "That's wrong; give me a different answer." You can help guide the class toward the right sort of answers by responding more to reasonable predictions than to irrelevant ones. Finally, when it's time to test the predictions, do it without a great deal of fanfare. Some predictions are right and others are wrong, but don't let the children dwell on this; move on quickly to another open-ended question. Keep the prediction process fun and non-threatening; making a wrong prediction is not a big deal, and it's even quite common. Also you may also ask questions for which there is no immediate answer, such as "Which plant will grow the tallest?" By repeated exposure to open-ended questions, children will learn that they can make predictions without fear of ridicule or future consequences for being wrong.

Additional scientific ways of talking can be introduced to the class in a similar manner to predictions. You can teach children how to test a prediction, how to explain why something happened, and how to compare two or more things. You can teach them to make connections between different events or ideas by asking what they have in common: for example, both candles and butter melt when they get hot.

Introducing Scientific Ways of Working

Measurement. As described above in the "Getting Ready" section, we have found that children readily learn about and enjoy using measurement tools. The easiest tool to work with is a ruler (Yardsticks are not as good, because they often become swords). Rulers are a safe size and they allow the child to put numbers to the world by measuring. They also let you compare objects that can not be moved (e.g., the height of one plant vs. another).

Observational Tools. A variety of tools can allow children to extend their senses. Magnifying glasses can let them see fine detail, light tables can let them see the internal structure of thin objects such as leaves, and microscopes can let them see objects which are invisible to the naked eye.

Journaling. We have found that science journals are an excellent tool for facilitating scientific ways of thinking. Children can record their experiences during activities. They can use their journals to compare things and to track long-term activities over time (such as growing plants). We began by announcing that every child would get a science journal when he or she asked for one, and this got most of them excited about choosing one to be their own. Once children requested a journal, they got to put their name on the back cover. A simple activity (drawing apples of different colors) got the children off to a good start, and we immediately used the drawings as concrete props in an Activity which involved predicting the taste of an apple from its color. Science journals were kept separate from the art area, and we brought them out in connection with specific science-related activities, but we always allowed children to draw whatever they wanted to. Journals need to be readily accessible (near the door, for use in outdoor activities), and should be stored with pens.

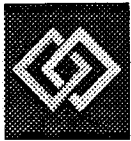
Keeping Track. We used date stampers in conjunction with journals; children did a lot of stamping just for fun in the beginning, but soon they used them correctly to mark the date of each drawing, once per page. Finally, we encouraged children to talk about their drawings, and we wrote down what they said next to their pictures. We emphasized the fact that scientists date their journal pages. So that children could do this themselves, we taught them how to use a date stamp.

Self-evaluation

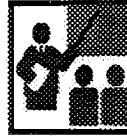
As already mentioned, implementing the PPS framework is a flexible, unfolding process that never happens the same way twice. With each passing year, you will learn more about what things work well and what things don't. Unlike a fixed curriculum, the PPS framework lets you readily integrate your insights and make improvements the next time around. Something that didn't work well as a Central Concept could be tried the following year as a Conceptual Focus, or dropped entirely. If your class found a particular Activity to be extremely engaging, you might try expanding it next year into an entire Conceptual Focus. A very successful and broad Conceptual Focus might even be expanded into a Central Concept. Use the flexibility of the PPS program to your advantage, to make talking, thinking, and working with scientific ideas fun and exciting each year!

Section 4. Sample Activities and the PPS Framework

Icon Legend



**Connect
to
Framework**



Facilitating



**Planning/
Brainstorming**



**Recording/
Journaling**



**Predicting/
Testing**



Observing



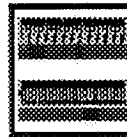
Comparing



Explaining



**Exploring
and
Discovering**



**Measuring/
Counting**



Connecting

Activity 1: Cutting Open Fruits and Vegetables

Summary: Various fruits and vegetables were set on a table outside. Children cut open the fruits and vegetables to find out which ones had seeds inside. Children recorded their results on a felt board by putting felt pictures of the fruits and vegetables on either the "Seeds" side or on the "No Seeds" side of the board.



Connect to Framework

This Activity was one in a series of activities with a common Conceptual Focus: "Fruits and Vegetables." The Central Concept that we explored through this activity was "Insides and Outsides."



Planning/ Brainstorming

The class has been talking about fruits and vegetables and some related terms such as seeds, roots, and sprouts. We wanted the children to observe and explore the key difference between fruits and vegetables: fruits have seeds on the inside, and vegetables do not.



Facilitating

As the children were cutting the fruits and vegetables, we encouraged them to make comparisons ("Do they feel the same? Taste the same?") and to make predictions about whether there were seeds inside. ("Here is an eggplant. Let's make a prediction. Does it have seeds or not?")



Observing

Children observed the insides and outsides of fruits and vegetables. Based on their observations, the children decided whether the fruits and vegetables contained seeds on the inside or not.



Predicting/ Testing

Children made predictions about whether a particular fruit or vegetable had seeds inside, and then cut it open to test their predictions. Some children even found new ways to test their prediction. For example, one child individually peeled each leaf of a cabbage off to see if there were any seeds in between.



Recording/ Journalling

After testing their predictions, children put a felt picture of the fruit or vegetable they cut on a felt board, dividing those with "seeds" from those with "no seeds". They also drew pictures of the activity in their journals.



Explaining

At the end of the activity, children discussed what each group on the felt board had in common, and the teacher explained that the "ones with seeds" are called fruits and the "ones without seeds" are called vegetables.

Activity 2: Exploring the Inside and Outside of a Fish

Summary: Children did three different activities with a fresh from the super market trout. At one table they colored outlines of the fish and made prints of fish on paper. At another table, children took the bones out and made "fossils" by pressing the bones into clay. At the third table, children cooked and ate the trout.



Connect to Framework

This Activity was one in a series of activities during a multi-week period with a common Conceptual Focus: "The Body." The Central Concept we explored through these activities was "Insides & Outsides."



Planning/ Brainstorming

While working on the concept of Insides and Outsides, the children asked questions about the inside and outside parts of animals such as their skin and bones. We felt that using a fish was a good way to begin answering many of these questions.



Facilitating

We also encouraged the children to observe and examine the inside and outside of the fish. We showed the children the inner parts of the fish and helped them take out the bones. We also encouraged the children to predict what would happen to the fish when it was cooked.



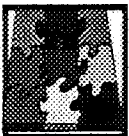
Observing

Children explored the inside and outside of the fish. Some observed the fish more closely through a magnifying glass and others compared their tracings with those of other children's.



Predicting/ Testing

One of the children near the cooking table predicted that the trout would change color after being cooked. Later, the child was able to test her prediction when we cooked the fish.

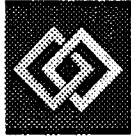


Connecting

Children noticed and discussed that the fish shared many common inside parts with other things we had seen while working with the Conceptual Focus of "The Body". The children learned that "inside the fish, like inside the human body, there are bones, meat, and muscles."

Activity 3: Listening to the Body with Stethoscopes

Summary: Children used stethoscopes to listen to their pulse, heart beat, lungs, stomach and other parts of their body as well as other objects in the classroom.



Connect to Framework

This Activity was one in a series of activities with a common Conceptual Focus on "The Body." The Central Concept explored through these Activities was "Insides & Outsides."



Planning/ Brainstorming

The class had just finished an earlier activity that involved looking at the insides and outsides of fruits and vegetables. That activity triggered the question, "What do people have inside?" Since we can not look first hand, we decided to use stethoscopes to listen to the human body.



Facilitating

As children were listening to their bodies, we talked about different parts inside our bodies that make noise. Children listened to their digestive tract while they ate apples. They heard the noises their bodies made through their cheeks, throats, and stomachs as they chewed and swallowed.



Comparing

Children also used stethoscopes to compare the sounds of other surfaces such as the table and floor to the sounds of their bodies. They talked about the similarities and differences between the sounds they heard (or did not hear). One child even brought in an X-ray from home and compared the film to what he had heard.



Connecting

In a previous "Inside & Outside" activity, children disassembled a typewriter. With this activity they could see and make a connection that there are "many different parts inside our bodies, just like in the typewriter." Children talked about the functions of different parts of our bodies, saw pictures of those parts in a book, and with this activity could also listen to the sounds these body parts make.

Activity 4: Casts On Fingers and Elbows

Summary: Children discovered what happens when we can not bend a finger or elbow. They made plaster finger casts, and then were tried to do different things (e.g., coloring) with these casts on. In another related activity, children wore casts (hollow tubes) on their elbows, and tried to touch their elbows to their knees, ears, legs and other body parts.



**Connect
to
Framework**

“Casts on Fingers and Elbows” was one of the Activities for a Conceptual Focus on “The Body.” The Central Concept explored at that time was “Insides & Outsides.”



**Planning/
Brainstorming**

We asked a local veterinarian for animals' X rays. Hanging real X-rays on the windows allowed children to see the “insides” of different animals. During Group Time sessions, they guessed what kind of animal the X-ray was a picture of, based on the bone structure they saw.



Facilitating

Before the activity, we talked about the joints in our body and the purpose they serve. We asked children to perform different activities with the finger casts on, and then to explain how and why working with their fingers became more difficult.



**Predicting/
Testing**

Children predicted and tested how wearing the finger casts would affect their ability to perform different activities such as coloring, picking up small things, or moving their fingers.



Explaining

After discovering what happens when we can not bend our fingers or elbows, children tried to explain why we need joints.

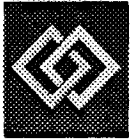


Connecting

In another activity, children in a carpentry workshop used hammers, nails, saws, etc. They were shown how to use hinges to connect two pieces of wood. During this “Casts Activity”, children were able to draw the connection between the function of hinges and joints.

Activity 5: Taking Apart a Typewriter

Summary: Children took apart a typewriter, using screwdrivers of different sizes, pliers, and other tools. During group time sessions, children discussed what they discovered while taking the typewriter apart. The typewriter was on a table in the class or in the yard for several days. Next to it, there was a book with a detailed picture of the “inside of the typewriter.”



Connect to Framework

During the period we explored the Central Concept “Insides & Outsides” Our Conceptual Focus was on the inside of animate objects (the human body, fish, etc.), and we wanted the children to explore the inside and outside of an inanimate objects as well.



Planning/Brainstorming

To explore the inside of an inanimate object, any machinery piece would work. We chose a typewriter because it was available, and because we had pictures of the “inside” of it. We found it important to offer Focus topics that would appeal to various interests. Tools and gadgets appealed to some, while cooking projects attracted others.



Facilitating

We showed children how to use the tools (“This is called a nut, see how it turns using the screwdriver?”, “Maybe you need the pliers to pull that up?”). We encouraged them to explore the typewriter’s different parts and to talk about their function (“What part is that do you think? What do you think the ribbon with ink is for?”).



Exploring/Discovering

Children explored the typewriter by taking it apart. They enjoyed discovering its parts- “Look at what I found...Here is another one”. Another child commented about one of the pieces: “First it was inside and then I took it out. I used the screwdrivers.”



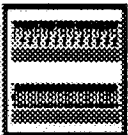
Comparing

Children were holding the screwdrivers in their hands to compare their size. They also compared the different sections of the typewriter as they took them out, for example how the buttons were different from the keys.



Explaining

During group discussions that followed the Activity, children (guided by the teacher) explained to the class what parts they found, how they were connected and taken part, and what they thought the function of those parts were.



Measuring/Counting

One of the children counted the number of pieces he had taken apart. Another measured each screw to find the smallest.



Connecting

Children noticed that the body has moving parts and machines have moving parts, however the mechanisms for movement are different.

Activity 6: Mechanical Hand

Summary: The mechanical hand is an artificial hand with plastic finger segments connected by small screws. We bought it at a local toy store. Children tried to use the mechanical hand to pick up small objects.



Connect to Framework

Work with the mechanical hand helped children explore the inner parts of the hand and their functions. It was one of the Activities under the Conceptual Focus of “The Body” within the Central Concept of “Insides & Outsides.”



Planning/ Brainstorming

Having completed several activities with foods (e.g. fruits and vegetables and cooking trout), we wanted to expand our projects to include tools and gadgets.



Facilitating

Our questions directed children to think about the differences between the real hand and the mechanical hand: “Can this hand work without you?” “Can this hand do anything your hand can do?”



Exploring/ Discovering

First, children saw a picture of the mechanical hand in a book. Then, they saw the mechanical hand during Group Time discussion. Finally, children explored it closely as they used it to pick up small cubes or to take apart a typewriter.



Comparing

Children discovered the similarities and differences between the mechanical hand and their own hand.



Explaining

Children explained: “The mechanical hand needs our muscles to move.” “It can’t move by itself.”

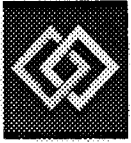


Connecting

Some children could draw the connection between the hinges used with wood in the hinge Activity, the mechanical hand, and the human hand.

Activity 7: Stomach Drawing

Summary: Children received a sketch drawing of the stomach system and were asked to draw what they thought was inside their stomachs. On the same table, there was a book on the human body with pictures of the body's different parts.



Connect to Framework

Stomach Drawing was one Activity in a series of activities with a common Conceptual Focus- "The Body". The Central Concept explored through these activities was "Insides & Outsides".



Planning/ Brainstorming

We had been discussing the insides of our bodies and had earlier listened to our stomachs with stethoscopes. This activity gave children a chance to make drawings based on what they had heard.



Facilitating

We asked children to explain what they were drawing, and we wrote their responses down next to their pictures. We also helped children look for pictures of the stomach in the book.



Comparing

One of the children compared his drawing to the one in the book. Then he pointed to his stomach, showing where it was located in his body.



Explaining

Some of the children's explanations of their drawings included, "The food comes from here, and it is going all the way here." "The pink makes the food go down." "Blood in the stomach makes you alive." "Inside my body there is a gooey mix and it goes down here."

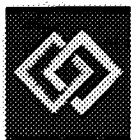


Recording/ Journaling

The teacher wrote down what each child said in their journal. The entry included the names of the parts in the picture and each function as the child explained them.

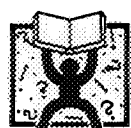
Activity 8: Fruits & Vegetables on a Felt Board or in Bowls

Summary: Felt pieces of fruits and vegetables were placed on a felt board (unsorted). Children sorted them in two ways, either by putting the ones with seeds on one side of the board, and the ones without seeds on the other side or into two different bowls, one for “seed soup” and the other for “no seed soup.”



Connect to Framework

During the week our Conceptual Focus was on Fruits and Vegetables. Activities included having children sort fruits and vegetables, cut them open, and cook soups. The Central Concept explored through these activities was “Insides & Outsides.”



Planning/ Brainstorming

Songs and stories at group discussions helped to set the stage for this activity. Children’s homework was to bring fruits and vegetables (real) to class. We started with basic grouping and sorting activities, which children do automatically, to give them a sense of accomplishment; for example, we made a graph of the fruits and vegetables the children brought to see which were the most popular.



Facilitating

As children were sorting the fruits and vegetables near the board, we helped them draw a connection between this activity and other “Fruits and Vegetables” activities: for example, “Yesterday, you were cutting open an apple. Do you remember what you found inside?”



Comparing

Children were encouraged to make comparisons: “What is the difference between this side [seeds] and that side [no seeds] of the board?”



Explore and Discover

Children argued about whether the eggplant needed to be placed in the “seeds soup” or “no seeds soup.” We brought a real eggplant to class and the children cut it open to discover the answer.

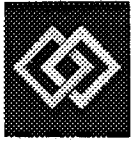


Recording/ Journaling

The felt board served as a tool for the children to record findings from the “Cutting Open Fruits & Vegetables” activity. Children placed a felt version of the fruit or vegetable they cut on the board, either in the “seeds side” or in the “no seeds side.” They also sorted them into their “soup” bowls using the same criteria. The children’s findings were also described in their journals through drawings of the fruits and vegetables.

Activity 9: Planting Sunflowers

Summary: Children planted sunflower seeds in the garden. They used small hand shovels to dig holes for the seeds, and rulers to measure the hole's depth. In the following months, children recorded the changes in their journals and we took pictures of the plants as they grew. At the end, the children used the harvested seeds to make their own seeds packets.



Connect to Framework

This Activity Focused on "Growth" which was a part of our Central Concept of "Change."



Planning/ Brainstorming

During group time we read stories about growing and planting seeds. One of the books we read was Eric Carle's story "The Tiny Seed". We asked children what they already knew about seeds such as, "What kind of plant will grow from a sunflower seed?" We formed a theory through the children's responses and then tested it by planting the seeds.



Facilitating

We encouraged the children to predict how the seeds would change and encouraged them to observe, measure, and record the changes in their journals.



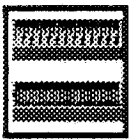
Observing

Children observed the sunflower plants as they were growing and blooming.



Predicting/ Testing

Children made predictions about the seeds in answering simple questions such as, "How fast will they grow?" "Which one will bloom first?"



Measuring/ Counting

Children used rulers to dig 6 inch holes in the ground. Measuring tools, such as rulers and magnifying glasses were made available to measure the sunflower plants as they grew. In his journal, one child compared the height of the sunflower with that of a teaching assistant.



Recording/ Journaling

Journals were always available outside, so that children could draw pictures of the plants on different days for later comparisons. We also photographed the sunflowers at different stages so that we could later form a time-sequence display of the plants' growths and changes.

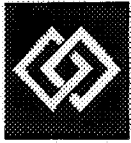


Connecting

Children inferred that, "different seeds grow different plants." Planting sunflowers enabled children to follow a complete cycle of plant growth; from seed to a tall plant and then back to a seed again.

Activity 10: Seeds in Wet /Dry tubes

Summary: Children grew lima bean seeds under two different conditions by varying the amount of water given (lots, medium, very little) and the size of the pots (big, small) . For this project the children used seeds, dirt, soil, and pots.



**Connect
to
Framework**

We had different Activities with seeds such as, sorting different seeds, planting lima beans in pots, and planting sunflower seeds in the yard. Our Central Concept was "Change" and the Conceptual Focus was on "Growth." We talked about how seeds change as they grow into sprouts and develop flowers and fruits.



**Planning/
Brainstorming**

One of the children shared an experiment he did at home, in which he put seeds in two different tubes (one with water and one without) to test if there would be a difference in the rate of growth. This motivated us to create an activity that was an extension of the child's original experiment.



Facilitating

For this activity we expanded on the children's ideas. For example, we had two pots and we asked the children, "Do you think there will be a difference if we add a lot of water to one and only a little to the other?" We also varied the sized of the pots and asked the children whether they thought the size of the pot was important.



**Predicting/
Testing**

Children predicted which seeds would grow the best. One of the children made a prediction about the "no water" pots: "Some will die and some will not." Another child predicted that the seeds in the smallest pot would grow the best- "because the seeds are that size and the pot is little."



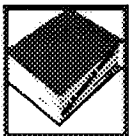
Observing

Children observed the pots from day to day and noted any changes. Some children used the magnifying glasses to observe the growth more closely.



Comparing

Children compared the sprouts in the big pots to the sprouts in the small pots to see which were growing faster.

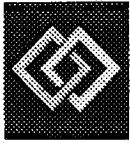


Record

Journals were always available next to the pots. Children recorded any changes they saw in their journals by drawing pictures of the plants on different days.

Activity 11: Growing Flower Bulbs

Summary: Children planted bulbs in pots. They monitored the growth of the plant stems by using rulers and magnifying glasses. They also recorded the changes in their journals.



Connect to Framework

This Activity of following the bulbs as the sprouted was part of the Conceptual Focus on "Growth." under the Central Concept of "Change."



Planning/ Brainstorming

We asked about forcing bulbs at the local nursery to help prepare for this Activity. We also made available books with pictures of bulbs at different stages of growth next to the pots. During Group Time discussions, we talked about how the bulbs sprout and grow.



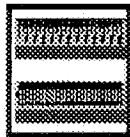
Facilitating

We directed the children's attention to the bulb table; "Bulbs grow and change. We'll start measuring how fast they grow." The rulers, magnifying glasses, and journals were always available next to the pots.



Observing

The bulbs were on a table either in the class or out in the yard, depending on the weather and the amount of space we had available. Children observed the bulbs from day to day and noted any changes.



Measuring/ Counting

Children used the rulers to measure the stems' growth. They also counted how many leaves each plant had and compared them to see which ones were the largest.



Recording/ Journaling

Children drew pictures of the bulbs in their journals, and we wrote their comments and thoughts next to their pictures.



Comparing

Journal drawings of the bulbs at different points in time enabled the children to compare the bulbs at different stages.



Connecting

Children connected their experience with the Central Concept of "Insides & Outsides" in this activity by peeling the flowers open to see if there were seeds or not.

VII. Appendices

Appendix A. Sample Parent Letter

Appendix B. Unexpected Directions

Appendix C. Ideas for Further Reading
(In Progress)

Appendix D. Examples of Teacher-Child Interactions
(In Progress)

Appendix A:
Sample Parent Letter Introducing PPS and Homework

Dear Parents,

We are writing to let you know about an exciting new program which we are including in your child's day at the Learn & Play Preschool. The program is called Preschool Pathways to Science (PPS), and was developed by preschool educators and cognitive developmental psychologists at the University of California, Los Angeles. The program consists of a series of connected activities throughout the year in which children will learn to make observations, comparisons, and predictions. We will be helping the children learn to think and talk about science-related questions, and to use words like "predict", "test", "measure", and "experiment." We will also emphasize connections between activities, such as applying similar questions and methods from one activity to another. Our goal is not to teach specific science facts, but to provide children with enjoyable experiences which give them the confidence to ask and answer science questions.

The PPS program will blend with the activities and daily schedule which we already have in place. We will spend part of Group Time introducing and discussing science-related topics, and then science-related activities will be a new option for the children during free play periods. Not every child is expected to participate on every day, but over the long run every child will experience and benefit from these activities.

Input from children plays an important part in the PPS program, since active learning is more successful and more fun than passive learning. One type of input which your child will be encouraged to give is the occasional "Show-and-Tell" homework assignment. For instance, if the class is talking about "things that change", your child may be asked to bring in photographs which show him or her at different ages. If the class is comparing fruits and vegetables, your child may ask you for a fruit or vegetable to share with the class. Don't be surprised if your child soon starts thinking of things to bring in without being asked at all!

We welcome your questions or input about this program, and we hope to have the opportunity to tell you more about it in person.

Sincerely,

Judy Walsh
Director, Learn & Play Preschool

Margaret Tompkins
Head Teacher, Class 4

Appendix B: Unexpected Directions

The PPS program is never boring for teachers, because of its dynamic balance between advance planning and emergent (child-directed) flexibility. One thing you can count on is that Activities will not always proceed the way you expected them to. This is a good thing, and not something to get agitated about; just try to relax and enjoy the ride, while also keeping your eye on the big picture of where you want to take the class in the PPS Framework. Below are two real-life examples of unexpected directions from our own experiences in the classroom.

Circle Time: noticing common features

The day after a field trip on which we collected bark from different types of trees, we displayed the bark pieces at Circle Time and tried to talk about which features they had in common. Our goal was to call attention to which ones were smooth or rough, which ones had holes or not, which ones were brown or black, and so on. What we did was to hold up two bark pieces at a time and ask the children, "How are these the same?" To our dismay, not a child would answer us. Repeating the question didn't help. Finally, one child said, "They're NOT the same." This produced an outpouring of helpful comments about how the bark pieces were different from one another, but we still wanted the children to be able to talk about the commonalities. No matter what we tried with the word "same," nothing worked. Later that day, during free play, we asked one of the children what she thought "same" meant. She thought for a moment, and then said, "If you have the same thing, they'll match." For her and the other children, "same" apparently meant "match", or in other words, "entirely the same."

Rather than giving up on our goal, the teachers met with each other and discussed how to rephrase our question in a way that would not set off the children's "matching" interpretation. After some trial and error, we were eventually successful at teaching children about "alike" and "in common", through a body-part labeling activity in which child and teacher put their arms next to each other. After asking "What do we both have", we were able to discuss commonalities (hand, fingers, elbow, etc.) as well as differences (freckles).

This experience reminded us that children do not always interpret our words in the way we expect them to. By listening carefully and identifying the word we were using that gave them difficulty, we were able to modify our original Activity and achieve its goal.

Activities: give the children time to explore the materials first

One summer day, we filled a circular channel with water and put in some small toy boats. Our goal was to demonstrate the concept of water current; by moving the water with our hands, we could start a circular current which would carry the boats around the loop. The activity was successful up to a point: children were making the boats move by pushing the water, and they were actively building dams with drinking straws to wall off small side channels from the main current. Still, we felt that the children were not grasping the concept of the current very well because they could not directly see it. One of us came up with the idea of cutting up some straws into little pieces and putting them in the water, in order to make the current more visible. Unfortunately, as soon as we put out scissors and more straws, the activity fell apart entirely and the children simply enjoyed cutting the straws into tiny pieces.

This experience reminded us that children need time to explore the materials for an activity in advance. Children were already familiar with the channel and boats, so they were able to use them in our water current activity. As soon as we starting cutting up straws, however, we had added a novel and highly distracting ingredient to the activity. Next time, we might try using more familiar objects as a way of making the water current visible, such as many small floating leaves.

**Appendix C:
Ideas for Further Reading**

Appendix D: Example of Teacher-Child Interactions

While using the Preschool Pathways to Science, we were amazed at how enthusiastically and critically the children thought about each Activity, Conceptual Focus, and Central Concept. Here are just a few examples of how the children integrated what was discussed while using the PPS Approach and how they expanded upon these ideas.

When Working with the Central Concept of "Insides & Outsides";

A child looking at a great hole where the floor was being repaired turned and asked the teacher, "Is it the inside of the floor or the outside of the ground?"

While studying the Central Concept of "Change";

Another child watering a sunflower said, mostly to himself, "Now you might wonder why we put the water on the ground when we want the water in the plant?" Then answering himself he said, "You see, there's a kind of plant muscle inside the plant just like there's a muscle here in my arm. See how my arm can squeeze? (demonstrates) Well, the plant muscle just sort of squeezes and squeezes that water all the way up to the top."

A four year old talking about a trip to the museum shared with the class, "My dad showed me the long line (time line). They left out the knights in the shining armor." The teacher then asked, "Where do the knights with the shining armor go?" The child replied, "Right before the regular people. See the fish with the bones on the outside go before the fish with the bones on the inside and the knights in the shining armor go before the regular people."